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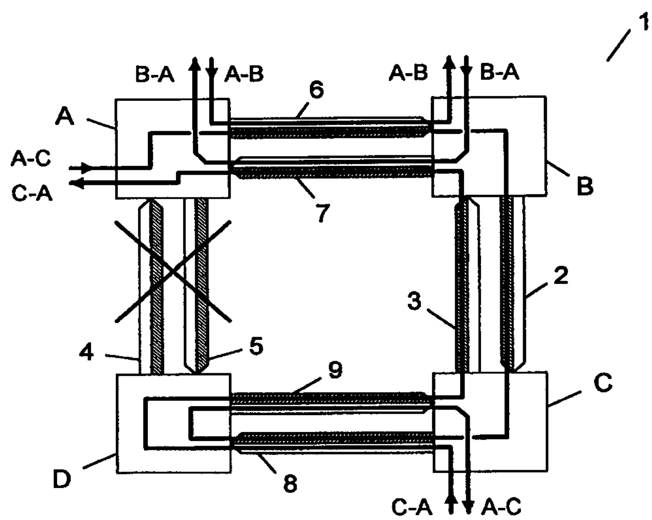

(57) Abstract

In a method of transmitting data in a ring–shaped teletransmission network (1; 11), such as e.g. an MS SPRing, a plurality of parallel primary channels (W1, W2, W3, W4) and secondary channels (P1, P2, P3, P4), respectively, may be transferred on the transmission lines connecting the network elements, so that a secondary channel is provided for each primary channel. Connections may be set up in the network so that a connection in each of the associated transmission lines uses one of the primary channels thereof, it being possible for the connection to use different channels in each transmission line. In case of drop–out of one or more transmission lines or network elements (K3), an auxiliary connection may be established via the secondary channels in the remaining transmission lines which connects the two network elements (K2, K4) that are closest to the dropped–out part of the network. In those cases where one of the connections set–up uses different primary channels on each side of a network element, the auxiliary connections are established in said network element via the corresponding secondary channels.

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A method of transmitting data in a ring-shaped teletransmission network, such a network and a network element therefor

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The invention relates to a method of transmitting data in a ring-shaped teletransmission network, wherein a plurality of parallel primary channels and secondary channels, respectively, may be transferred on the transmission lines connecting the network elements so that a secondary channel is provided for each primary channel, wherein connections may be set up in the network such that a connection in each of the associated transmission lines uses one of the primary channels thereof, but not necessarily the same channel in each transmission line, and wherein, in case of drop-out of one or more transmission lines or one or more network elements, an auxiliary or replacement connection connecting the two network elements closest to the dropped-out part of the network may be established via the secondary channels in the remaining transmission lines. The invention moreover relates to a corresponding network element and to a ring-shaped teletransmission network.

Today, ring-shaped teletransmission networks of the type described are used extensively in e.g. SDH networks (Synchronous Digital Hierarchy). The protection mechanism in such a ring-shaped network may e.g. be of the type 2-fibre MS SPRing (Multiplex Section Shared Protection Ring), where the active traffic is transported via the bi-directional working paths. In case of errors, interrupted traffic is transported via the bi-directional protection paths in the opposite direction round in the ring. The great advantage of using MS SPRing is that with specific traffic patterns the capacity of the ring is greater than if other known protection mechanisms were

used, such as e.g. MS DPRing (Multiplex Section Dedicated Protection Ring) or SNCP (Sub Network Connection Protection).

In case of an error, the working traffic which is transmitted in the direction toward the error is connected in a node (network element) close to the error into the protection path in the opposite direction away from the error. This is also called "head end bridge". The traffic is re-created in the node on the other side of the error by coupling the protection traffic which is transmitted in the direction toward the error into the working path in the opposite direction away from the error. This is also called "tail end switch".

This principle works satisfactorily for normal connections in the network; but it has been found that problems may occur when so-called time slot interchange is used at the same time in the network, which means that an established connection does not necessarily use the same channel or time slot during its entire course in the ring, as a change may take place en route from one channel to another in a network element and back again in another network element, e.g. because the first channel is used by another connection on part of the stretch.

The problem is that if an error occurs in this situation causing drop-out of one of the network elements in which such a time slot interchange occurs, the MS SPRing mechanism will connect the interrupted working path to two different auxiliary channels by head end bridge and tail end switch, respectively, and since these auxiliary channels are not interconnected, the connection cannot be re-established and thus the traffic cannot be maintained.

Accordingly, an object of the invention is to provide a method of the type stated in the opening paragraph wherein the traffic can be maintained even if a network element in which channel change takes place, drops out because of an error in the network.

This is achieved according to the invention in that, in those cases where one of the connections set-up uses different primary channels on each side of a given network element, the auxiliary connections are established in the network element concerned via the corresponding secondary channels.

When the secondary channels in the individual network elements are connected in the same manner as the primary channels, it is ensured that the reserve connection in the non-error network elements changes channel in such a manner that the described situation is compensated.

As mentioned, the invention also relates to a corresponding network element and a ring-shaped teletransmission network which are described in claim 2 and claim 3, respectively.

Physically, the network may be constructed in many different ways; but the invention will be of particular importance when, like in claim 4, an optical network is involved, as these frequently transmit huge traffic amounts, and, therefore, drop-out will cause huge data amounts to be lost if the traffic cannot be maintained. In an expedient embodiment, which is defined in claim 5, each transmission line is formed by an optical fibre for each transmission direction; but a single fibre may also be involved in which transmission takes place at two different wavelengths in different directions.

The parallel channels of the network may be produced in different ways. As stated in claim 6, e.g., they may be parallel channels in a time-division multiplex system, or, as stated in claim 7, each channel may be transmitted at an independent wavelength in a wavelength-division multiplex system. Further, as stated in claim 8, the parallel channels may be transmitted in a plurality of parallel cables.

The invention may likewise find use in connection with various transmission protocols; such use may e.g. comprise transmission of data according to a Synchronous Digital Hierarchy (SDH), as stated in claim 9, and the design may then expediently be in the form of an MS SPRing, as stated in claim 10. Alternatively, a SONET system may be involved.

If, as stated in claim 11, the secondary channels can be used for the transmission of low priority data traffic in normal operation, and this traffic can be interrupted to accommodate said auxiliary connections in case of drop-out of one or more transmission lines or one or more network elements, an increased transmission capacity is achieved under normal conditions of operation. This may e.g. be utilized by data which are not sensitive to delays in the transmission, and which can therefore be interrupted when the channels are needed for the described use. Alternatively, as stated in claim 12, the secondary channels may be reserved for the said auxiliary connections, thereby always ensuring that they are available when needed. Furthermore, this solution requires less administration on the part of the control system.

The invention will now be described more fully below with reference to the drawing, in which

fig. 1 shows a known network in which the invention may be used,

fig. 2 shows the network of fig. 1 in a first error situation,

fig. 3 shows the network of fig. 1 in a second error situation,

fig. 4 shows a corresponding network having six nodes,

fig. 5 shows an established connection in the network of fig. 4 in normal operation,

fig. 6 shows an error situation in the same network,

fig. 7 shows an example of time slot interchange,

fig. 8 shows another example of time slot interchange,

fig. 9 shows a connection using time slot interchange,

fig. 10 shows what happens to the connection of fig. 9 in an error situation,

fig. 11 shows how the protection channels may be set up according to the invention, and

fig. 12 shows what happens to the connection of fig. 11 in an error situation.

Fig. 1 shows an example of a known network 1 in which the invention may be used. It is an MS SPRing (Multiplex Section Shared Protection Ring) having two optical fibres, which is a network type that is typically used in an SDH network of the type which connects a telephone exchange

to its subscribers. The ring is shown here with four network elements or nodes A, B, C and D. For example, the two network elements B and C are connected by the two fibres 2 and 3, of which the fibre 2 transmits in a direction from B to C, while the fibre 3 conversely transmits in the direction from C to B. Correspondingly, the network elements A and D are connected by the fibres 4 and 5, A and B by the fibres 6 and 7, and C and D by the fibres 8 and 9. Each fibre transfers working traffic as well as protection traffic. The capacity of each fibre is here divided equally between working capacity and protection capacity; but situations are also conceivable where a greater part of the capacity is used for working capacity if protection is desired for only part of the working capacity. The working capacity is shown in white in the figure, while the protection capacity is shown hatched. Fig. 1 shows the ring in the normal situation where only the working capacity is used, and it appears that working traffic is transferred between the nodes A and B as well as between the nodes A and C. The traffic is bi-directional, with transmission e.g. both from A to B and from B to A.

For example, it is conceivable that an STM-1 frame is transferred from A to B and correspondingly in the opposite direction. Typically, however, the fibres will allow simultaneous transfer of several channels in the same fibre. This may take place e.g. by time-division multiplex where e.g. an STM-4 frame or STM-8 frame may then be transferred, it being possible to use each of the four or eight time slots for a channel. This will be described more fully below.

In case of an error, working traffic which is transferred in a direction toward the error, is looped or coupled at a node close to the error into the protection path in the

opposite direction away from the error. This is called head end bridge. The traffic is re-created at the other node close to the error by coupling the protection traffic, which is transferred in the direction toward the error, into the working path in the opposite direction away from the error. This is called tail end switch.

Fig. 2 shows an example of how this may look in case of a single fibre rupture. In this case, both of the two fibres 4 and 5 between the nodes A and D are interrupted. The bi-directional traffic between the nodes A and C, which is interrupted together with the fibres 4 and 5, will be re-created in the nodes A and D, as appears from the figure. In node A, head end bridge for the connection from A to C and tail end switch for the connection from C to A are performed, while, conversely, in node D head end bridge for the connection from C to A and tail end switch for the connection from A to C are performed. The traffic is thus detoured via the protection channels in the fibres 6, 2, 8 and 9, 3, 7 respectively.

It is shown correspondingly in fig. 3 how the situation may look in the event that a node drops out, which corresponds to a fibre rupture on both sides of a node. The error is shown in the node D in the figure. Here, too, the bi-directional traffic between the nodes A and C may be re-created, as head end bridge as well as tail end switch takes place in the nodes A and C in the manner described above.

It is described more fully below how the situation looks when a time-division multiplex system is used in a manner known per se. Fig. 4 shows the network 11, which here has six nodes called K1, K2, K3, K4, K5 and K6. Like in the figures 1-3, the nodes are connected by two fibres here too, there being used one fibre for each transmission di-

rection, each fibre accommodating working channels as well as protection channels. Since the established connections are bi-directional, as described above, we will, however, below just consider the two fibres as a transmission line having a plurality of time slots.

Fig. 5, in which the ring is shown in the open state for reasons of illustration so that the points on the left-hand side of K1 are connected to the right-hand side of K6, shows four working and four protection channels or time slots. The working channels are called W1-W4, while the protection channels are correspondingly called P1-P4. The eight channels or time slots thus correspond e.g. to an STM-8 frame. The figure shows the network in normal operation, and it appears that a connection is set up between the nodes K2 and K5 via the channel W1.

Fig. 6 illustrates a situation in which drop-out of the node K3 occurs (or a double fibre rupture around this node occurs) so that the transmission between the nodes K2 and K5 can no longer take place as shown in fig. 1. The traffic in the interrupted connection is therefore coupled into the protection channel P1 in the adjacent nodes, i.e. K2 and K4, in a direction away from the error in the same manner as described above in relation to fig. 3. Of course, an arbitrary one of the four protection channels might be used; but the simplest control is obtained when e.g. P1 is used in connection with an interrupted connection in W1. As will be seen, the established connection may thus be re-created without problems in this situation.

However, the situation is different if also so-called time slot interchange is used in the ring, and this will therefore be described briefly below. Fig. 7 shows an example where a connection is first established between the

nodes K3 and K4, it being then desired to establish a connection between K2 and K5. When a control system introduces traffic into the ring, i.e. sets up connections, it will often try to place a channel on the lowermost time slots in a given fibre. The first connection K3-K4 is therefore placed in the time slot W1. Instead of placing the connection K2-K5 in e.g. the time slot W2, the control system will therefore typically place the new connection as shown in the figure so that W1 is used from K2 to K3 and from K4 to K5, while W2 is used from K3 to K4 where W1 is occupied. Thus, time slot interchange or channel change takes place in the nodes K3 and K4.

Fig. 8 shows another example where a number of connections have already been set up, as shown in thin line. When it is subsequently desired to set up a connection between K1 and K4, the existing connections would prevent this if time slot interchange was not possible. With time slot interchange, the connection may be placed as shown in thick line in the figure, using the time slot W1 and the time slot W2, respectively.

Figures 9 and 10 show how the use of time slot interchange may be a problem when in case of certain error types it is attempted to re-create the traffic by means of the protection channels. The connection in fig. 9 corresponds to the one shown in fig. 7 and thus uses the time slot W1 from K2 to K3 and from K4 to K5, while W2 is used from K3 to K4. Thus, time slot interchange or channel change takes place in the nodes K3 and K4. Fig. 10 shows what happens when the node K3 is interrupted. In the node K2, the interrupted connection is coupled from W1 to the protection channel P1, as W1 was used between K2 and K3. In the node K4, the interrupted connection is correspondingly coupled from W2 to the protection channel P2, as W2 was used between K4 and K3. Since the protec-

tion channels P1 and P2 are not connected to each other anywhere else in the ring, both of the two protection channels will have one end unconnected, i.e. the connection cannot be re-established, as is also shown in fig. 10. This means that in this situation the protection ring does not have the intended effect, and the traffic will be lost.

Figures 11 and 12 show how this may be solved according to the invention. As appears from fig. 11, the protection channels, which are not used in this case, are set up in each individual node before or when an error situation occurs, so that they follow the corresponding working channels in the same node in those cases where time slot interchange takes place in the node concerned. Since a change thus takes place in the node K3 between the channels W1 on the left-hand side and W2 on the right-hand side, P1 on the left-hand side of K3 is correspondingly connected to P2 on the right-hand side of K3. The same takes place in K4, so that the protection channels in the same manner reflect the setting-up of the working channels. In the nodes and for the channels (time slots) where time slot interchange does not take place in the working channels, the coupling will merely be straight through like before so that e.g. P3 on the left-hand side is associated with P3 on the right-hand side of a given node.

If the node K3 now drops out, the interrupted connection is coupled in the node K2 from W1 to P1, as described before, since no time slot interchange took place in this node. In the node K4, the interrupted connection on the left-hand side is coupled like before from W2 to the protection channel P2, as W2 was used between K4 and K3; but since K4 has now been or is now set to connect P2 on the left-hand side to P1 on the right-hand side, the estab-

lished protection path on the right-hand side of K4 will extend in the channel P1 and thus correctly be connected to K2 the other way round in the ring so that the interrupted connection may be re-established.

The principle is that the setting-up of the protection channels in K4, because of the time slot interchange occurring in it, compensates for the corresponding time slot interchange in the node dropped out, i.e. here K3. The advantage is that each individual node just needs information on how it is set up itself with respect to time slot interchange. On the other hand, it is necessary that the established connections at the ends, i.e. closest to the nodes which are to be connected, use the same time slot, as shown here with the time slot W1 at both ends. Since the control system will frequently already be adapted to place connections in the lowermost time slots where these are free, it can also be adapted to place, as far as possible, the connections such that they use the same time slot at the outermost ends of the connection.

It should be noted that only a single connection is shown in the figure for reasons of clarity. In practice, several simultaneous connections will frequently occur, and, correspondingly, a large number of time slot interchanges will typically occur. Each individual node can therefore contain several of the set-ups shown in fig. 11.

Although a preferred embodiment of the present invention has been described and shown, the invention is not restricted to it, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims. For example, instead of the described MS SPRing having two fibres, other types of rings may be used, such as e.g. an MS SPRing having four fibres, or the ring may be adapted such that protection channels are

just provided for some of the active working channels. Furthermore, the individual channels may be transmitted at independent wavelengths in a wavelength-division multiplex system instead of in a time-division multiplex system, or they may be transferred on their respective parallel cables. Finally, it should be mentioned that in normal operation, i.e. without errors, the protection channels may be utilized for the transmission of low priority traffic, without this being of any importance for the mode of operation of the invention.

P a t e n t   C l a i m s :

1. A method of transmitting data in a ring-shaped tele-transmission network (1; 11) which is composed of a plurality of network elements (A, B, C, D; K1, K2, K3, K4, K5, K6) so that each network element is at least connected to two other network elements in the ring-shaped network by transmission lines,

and a plurality of parallel channels may be transferred on each transmission line, some of said channels forming primary channels (W1, W2, W3, W4), others of said channels forming secondary channels (P1, P2, P3, P4) so that a secondary channel corresponds to each of at least some of the primary channels,

wherein connections may be set up in the network between two network elements via a plurality of intermediate transmission lines and network elements so that a connection in each of the intermediate transmission lines uses one of the primary channels which has a corresponding secondary channel, it being possible for the connection to use different primary channels in each of said transmission lines,

and wherein, in case of drop-out of one or more transmission lines or one or more network elements (K3) in the ring-shaped network, an auxiliary connection may be established via the secondary channels in the remaining transmission lines for each of the connections set up via the dropped-out part of the network, said auxiliary connection connecting the two network elements (K2, K4) which, on their respective sides, are closest to the dropped-out part of the network, and which are connected in these network elements to the primary channels associ-

ated with the connection in a direction away from the dropped-out part of the network,

c h a r a c t e r i z e d in that, in those cases where one of the connections set-up uses different primary channels on each side of a given network element, the auxiliary connections are established in the network element concerned via the corresponding secondary channels.

2. A network element for a ring-shaped teletransmission network (1; 11) which is composed of a plurality of such network elements (A, B, C, D; K1, K2, K3, K4, K5, K6) so that each network element is at least connected to two other network elements in the ring-shaped network by transmission lines,

and a plurality of parallel channels may be transferred on each transmission line, some of said channels forming primary channels (W1, W2, W3, W4), others of said channels forming secondary channels (P1, P2, P3, P4) so that a secondary channel corresponds to each of at least some of the primary channels,

wherein connections may be set up in the network between two network elements via a plurality of intermediate transmission lines and network elements so that a connection in each of the intermediate transmission lines uses one of the primary channels which has a corresponding secondary channel, it being possible for the connection to use different primary channels in each of said transmission lines,

and wherein, in case of drop-out of one or more transmission lines or one or more network elements (K3) in the ring-shaped network, an auxiliary connection may be established via the secondary channels in the remaining

transmission lines for each of the connections set up via the dropped-out part of the network, said auxiliary connection connecting the two network elements (K2, K4) which, on their respective sides, are closest to the dropped-out part of the network, and which are connected in these network elements to the primary channels associated with the connection in a direction away from the dropped-out part of the network.

c h a r a c t e r i z e d in that, in those cases where one of the connections set-up uses different primary channels on each side of the network element concerned, the network element is adapted to establish the auxiliary connections via the corresponding secondary channels.

3. A ring-shaped teletransmission network (1; 11) which is composed of a plurality of network elements (A, B, C, D; K1, K2, K3, K4, K5, K6) so that each network element is at least connected to two other network elements in the ring-shaped network by transmission lines,

and a plurality of parallel channels may be transferred on each transmission line, some of said channels forming primary channels (W1, W2, W3, W4), others of said channels forming secondary channels (P1, P2, P3, P4) so that a secondary channel corresponds to each of at least some of the primary channels,

wherein connections may be set up in the network between two network elements via a plurality of intermediate transmission lines and network elements so that a connection in each of the intermediate transmission lines uses one of the primary channels which has a corresponding secondary channel, it being possible for the connection to use different primary channels in each of said transmission lines,

and wherein, in case of drop-out of one or more transmission lines or one or more network elements (K3) in the ring-shaped network, an auxiliary connection may be established via the secondary channels in the remaining transmission lines for each of the connections set up via the dropped-out part of the network, said auxiliary connection connecting the two network elements (K2, K4) which, on their respective sides, are closest to the dropped-out part of the network, and which are connected in these network elements to the primary channels associated with the connection in a direction away from the dropped-out part of the network,

c h a r a c t e r i z e d in that the network comprises means for establishing the auxiliary connections via the corresponding secondary channels in the network element concerned in those cases where one of the connections set-up uses different primary channels on each side of a given network element.

4. A network according to claim 3, c h a r a c t e r - i z e d in that it is an optical network.

5. A network according to claim 4, c h a r a c t e r - i z e d in that each transmission line is formed by an optical fibre for each transmission direction.

6. A network according to claims 3-5, c h a r a c - t e r i z e d in that each of the parallel channels is a channel in a time-division multiplex system.

7. A network according to claims 3-5, c h a r a c - t e r i z e d in that each channel is transmitted at an independent wavelength in a wavelength-division multiplex system.

8. A network according to claims 3-5, c h a r a c t e r i z e d in that the parallel channels are transmitted in a plurality of parallel cables.

9. A network according to claims 3-8, c h a r a c t e r i z e d in that it is adapted to perform transmission of data according to a Synchronous Digital Hierarchy (SDH).

10. A network according to claim 9, c h a r a c t e r i z e d in that it is constructed as an MS SPRing.

11. A network according to claims 3-10, c h a r a c t e r i z e d in that in normal operation the secondary channels (P1, P2, P3, P4) may be used for the transmission of low priority data traffic, and that this traffic may be interrupted to accommodate said auxiliary connections in case of drop-out of one or more transmission lines or one or more network elements in the network.

12. A network according to claims 3-10, c h a r a c t e r i z e d in that the secondary channels (P1, P2, P3, P4) are reserved for said auxiliary connections.

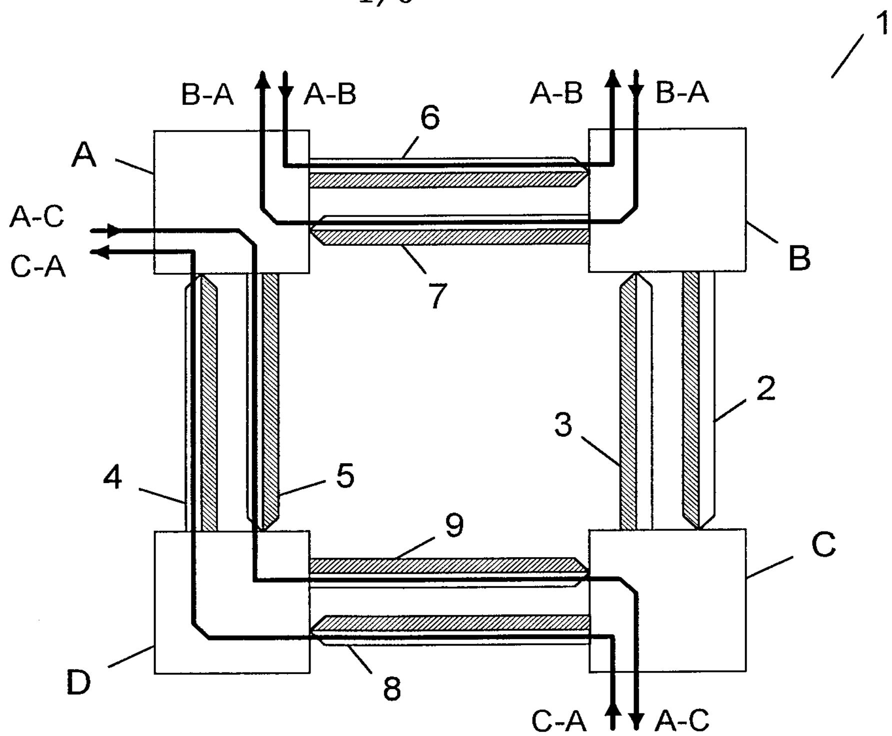
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Fig. 1

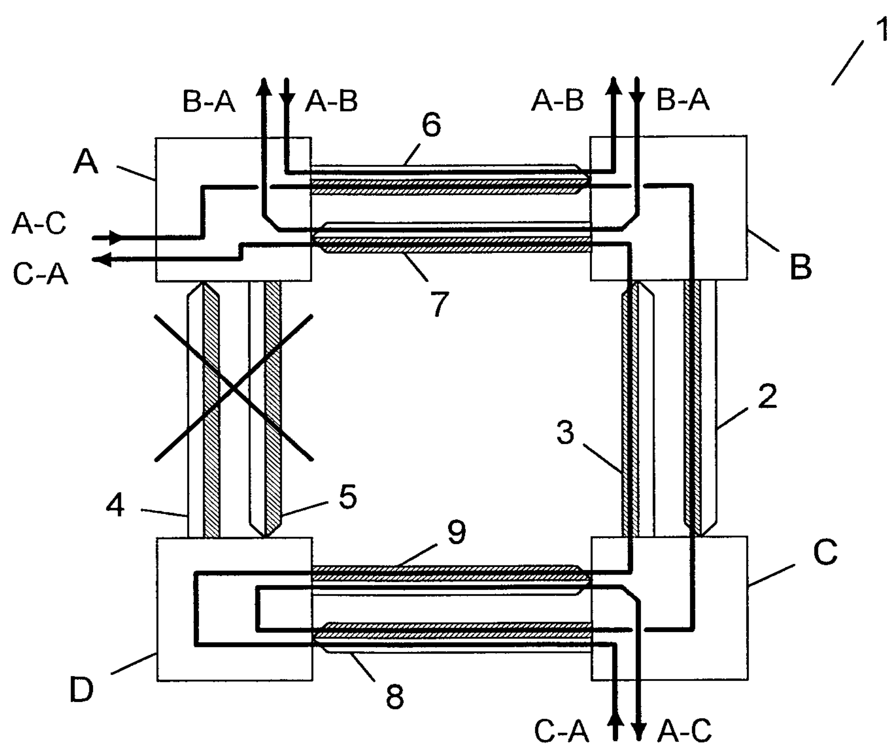
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Fig. 2

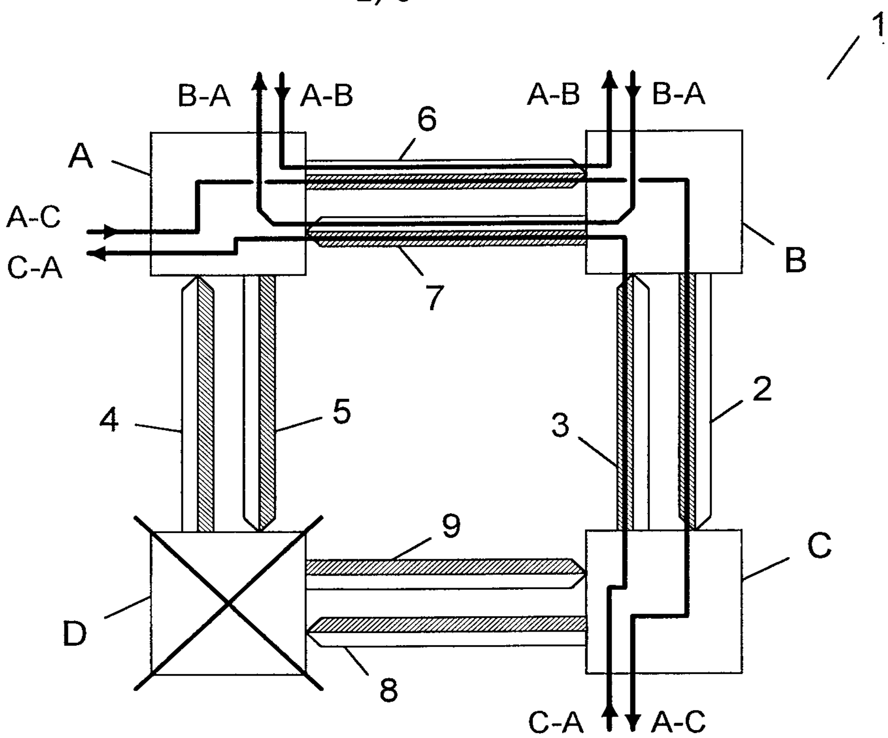

Fig. 3

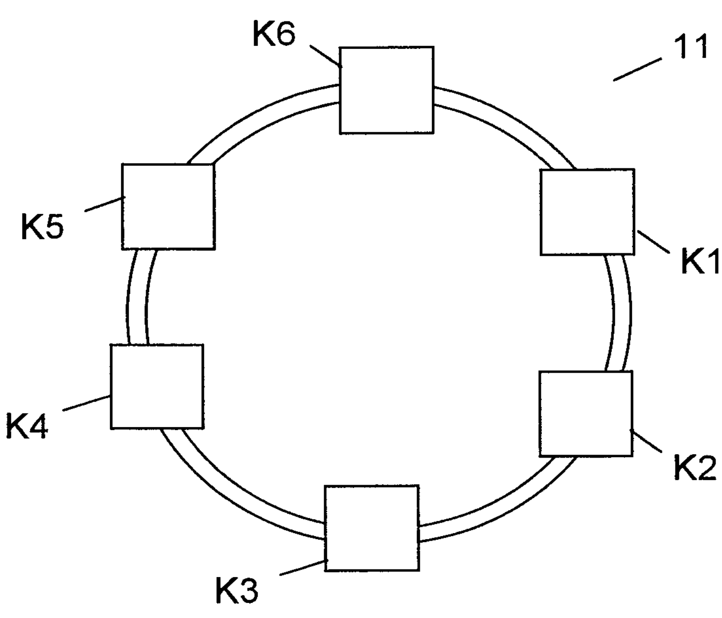

Fig. 4

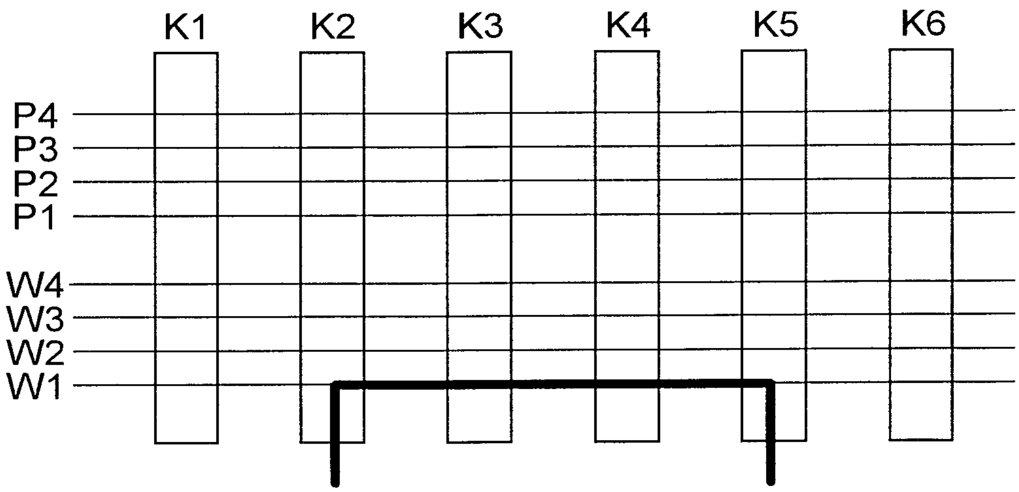
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 5

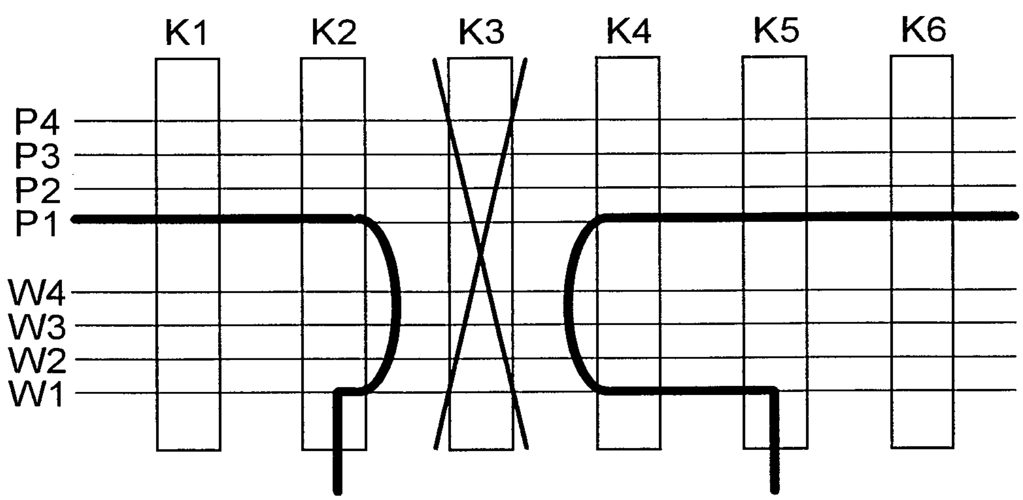
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 6

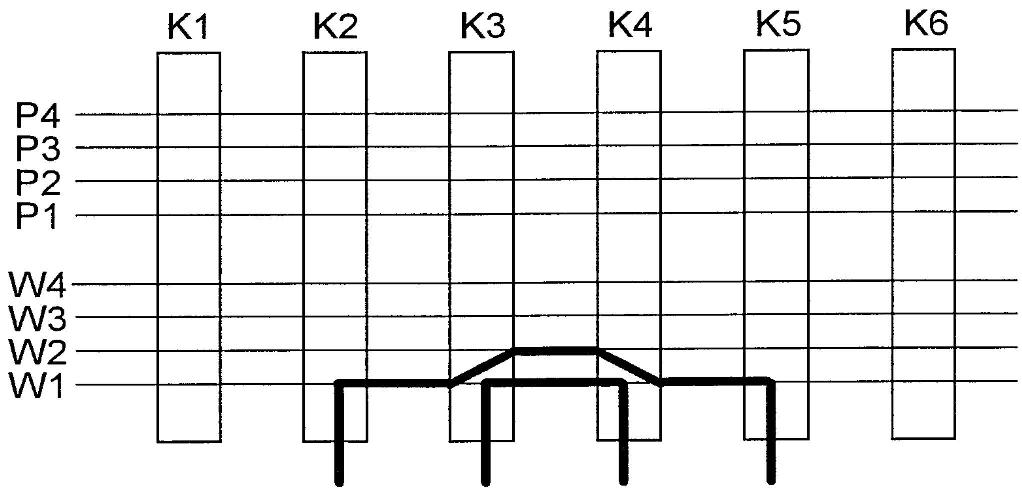
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 7

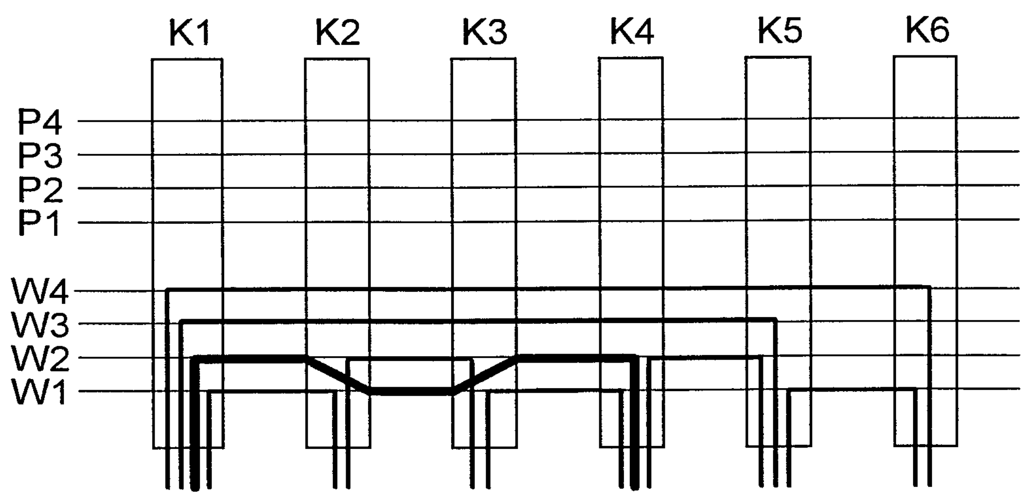
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 8

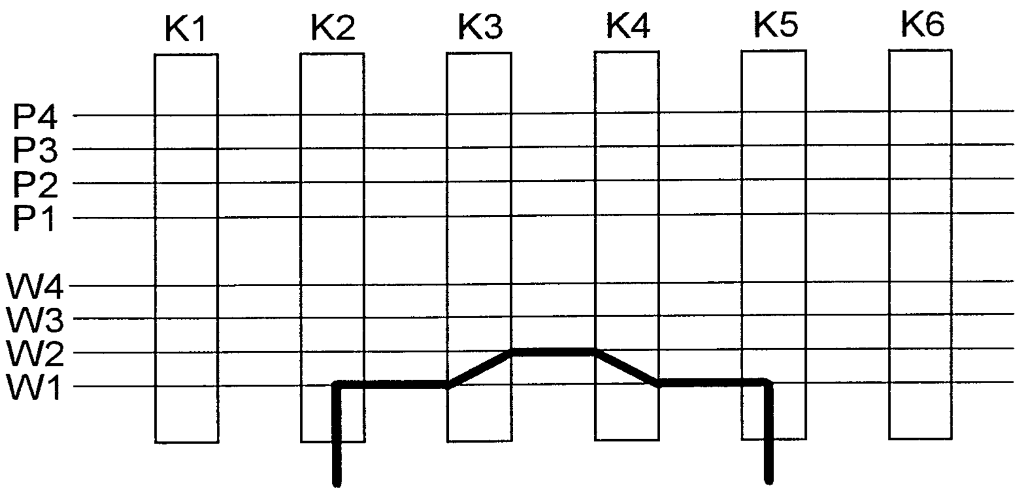
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 9

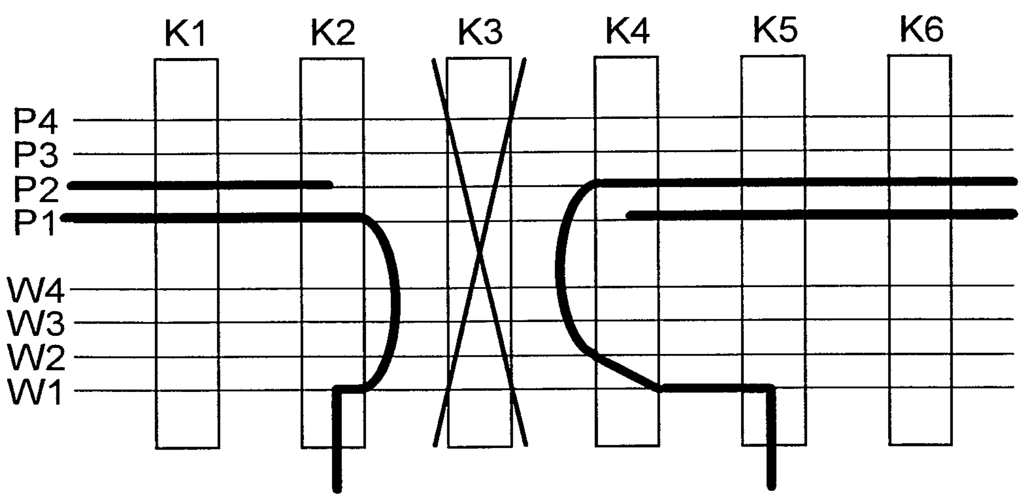
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 10

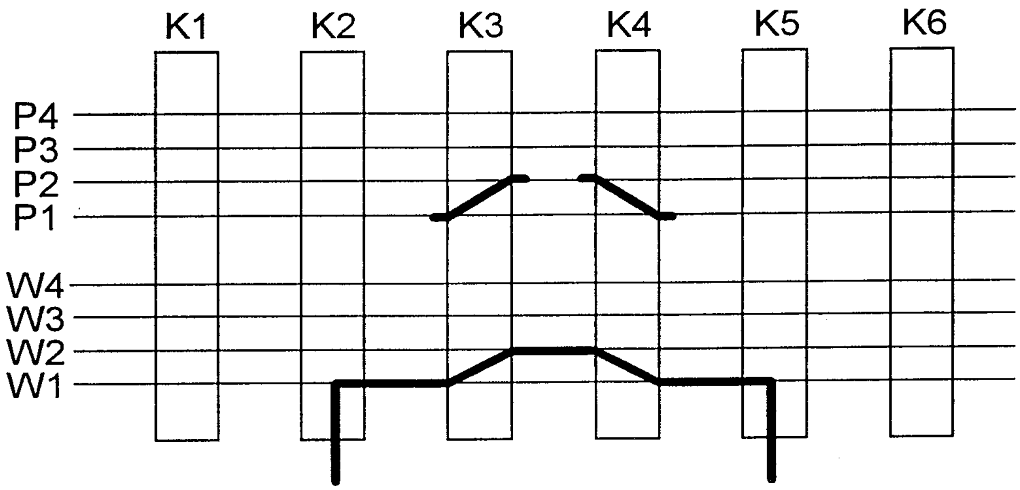
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 11

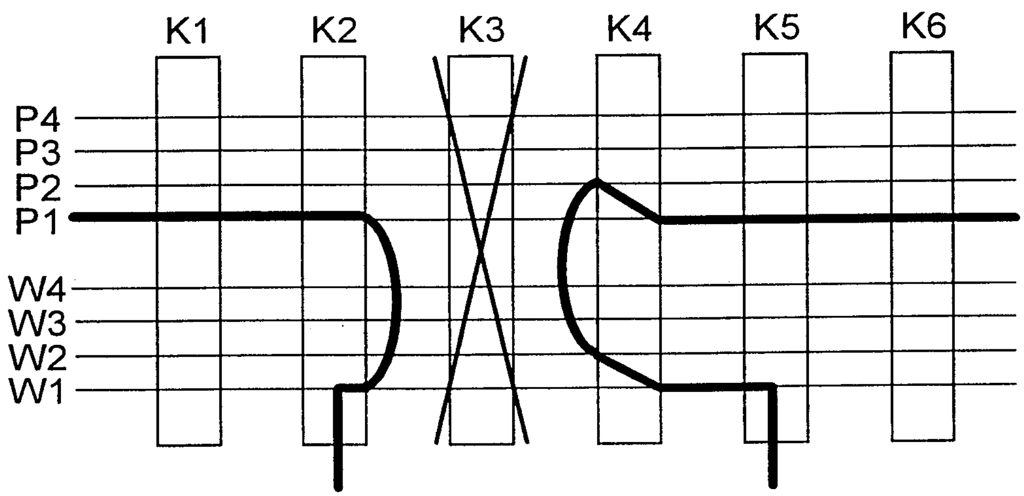
K1
K2
K3
K4
K5
K6
P4
P3
P2
P1
W4
W3
W2
W1

Fig. 12